Phase Diagram of PrPb$_3$ under hydrostatic pressure

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The low-temperature properties of Pr-based intermetallics with a non-Kramers doublet ground state are determined by nonmagnetic interactions. The cubic compound PrPb$_3$ exhibits antiferroquadrupolar (AFQ) order as previously seen by magnetization measurements and neutron scattering. We investigated the (B, T, p) phase diagram of PrPb$_3$ by measurements of the specific heat and the magnetocaloric effect. In zero magnetic field B the specific heat shows a second-order transition with an AFQ ordering temperature $T_{AFQ} = 0.39$ K in line with earlier results. The entropy for $B = 0$ reaches $R \ln 2$ near 1 K which is compatible with a doublet ground state. For $B \parallel \langle 100 \rangle$, T_{AFQ} as determined by the maximum in the specific heat increases to $T_{AFQ} = 0.66$ K in 6 T. Antiferromagnetic interactions between the field-induced staggered magnetic moments stabilize the AFQ phase and increase T_{AFQ} in an applied B. In addition to this second-order transition, we found a further transition at $T = 0.35$ K for 3 T and $T = 0.49$ K for 4.5 T, which, however, is only observed upon heating. The strong hysteresis between heating and cooling suggests that this transition is of first order. Further support comes from measurements of the magnetocaloric effect $\Delta T / \Delta B$ at fixed $T \approx 500$ mK and $T \approx 230$ mK as a function of B up to 6.5 T. Under hydrostatic pressure of 6.5 kbar the phase diagram is almost unaltered in agreement with an estimate of dT_{AFQ}/dp by Ehrenfest's relation.